GSJ: Volume 6, Issue 12, December 2018
ISSN 2320-9186


GSJ: Volume 6, Issue 12, December 2018, Online: ISSN 2320-9186
www.globalscientificjournal.com

# INVESTIGATE THE POST WAR IMPROVEMENTS OF HYDRAULIC INFRASTRUCTURE IN IRRIGATION SYSTEMS OF KANAGARAYAN ARU RIVER BASIN USING HYDROLOGICAL MODEL

***Janithra S., Pratheeba J., Athapattu B C L., Sampath D S., Sivakumar S S.,***

*S.Janithra, Student Department of Civil Engineering, Open University, Sri Lanka; janithrabavan@gmail.com*
*J.Pratheeba, Student Department of Civil Engineering, Open University, Sri Lanka; nimmi2nimmi6@gmail.com*
*B.C.L Athapattu Department of Civil Engineering, Open University, Sri Lanka; bcliy@ou.ac.lk*
*D S Sampath Department of Civil Engineering, University of Jaffna, Sri Lanka. E-mail: saliya@eng.jfn.ac.lk*
*S S Sivakumar Department of Civil Engineering, University of Jaffna, Sri Lanka. E-mail: sssivakumar@eng.jfn.ac.lk*

KeyWords: Kanagarayan Aru river basin, Iranamadu, Kanagarayan Kulam and Chemamadu Irrigation Scheme, HEC-HMS Hydrological Modeling



## ABSTRACT

Jaffna, Kilinochchi, Mullaitivu, Vavuniya and Mannar districts are under the Northern Province. Most of the northern region got affected due to the civil war around 30 years. Due to this war water resources development were damaged severely. The major, medium and minor irrigation systems were dilapidated conditions. After the resettlement stack holders are engaged with agriculture activities and several investments were done for the irrigation infrastructure. However still stack holders suffering with cultivation issues. Most of the area of the Northern Province has been used for paddy cultivation. During the dry seasons most of the irrigation schemes in this area became dry. Hence the command area of those irrigation schemes cannot be irrigated successfully for two seasons. As a consequence cultivated crops fail and farmers are affected heavily. Hydrological Modeling is a commonly used tool by water resources planners to simulate the hydrological response in a basin due to the precipitation for the purpose of management of basin water. With the increasing demand for limited water resources in every basin, careful management of water resources becomes more important. The Kanagarayan Aru River Basin in Srilanka supplies water to number of new and ancient irrigation systems and the management of water resources in the Kanagarayan Aru River Basin. total catchment area of this River Basin is 906Sq.Km. Important for optimum utilization of water for these irrigation systems in the project continuous rainfall-runoff modeling in pat of the Iranamadu Tank, Chemamadu Tank and Kanagarayan Kulam Tank. Storage Irrigation systems using the hydrological Engineering centre – Hydrologic Modeling System (HEC-HMS) VERSION 3.0.1 to estimate the runoff in the Kanagarayan Aru River

## 1.0 INTRODUCTION

The Northern Province comprises the whole of five districts namely Jaffna, Kilinochchi, Mullaitivu, Vavuniya and Mannar. Agriculture including fisheries has been the principal economic activity in the province. All most all the population of North part of Sri Lanka got affected due to the civil war in continued about 30 years. Most the irrigation schemes, roads and houses were damaged severe. Most of the population in this district was engaged in agriculture activities due to the displacement and after the resettlement people are back in their villages and started the cultivation activities. The major, medium and minor irrigation systems are in dilapidated conditions. The displaced farmers are fully depending on the farming activities of this area and they are facing severe problems for their irrigation issues to the cultivated crops. Since no water resources development were taken place for the past twenty years in this area. People are finding difficulties for consuming their water requirements for domestic and economic purposed.

### 1.1 Kanagarayan Aru River Basin

Kanagarayan Aru river Basin starts from Vavuniya district and ends with Kilinochchi Chundikulam Lagoon through Mullaitivu. Length of this River is 86Km. figure shown in Fig 1.1. The total catchment area of this river basin is 906 Sq.Kms. The major scheme in this river basin is Iranamadu tank. There are two medium schemes namely Kanagarayan Kulam, Chemamadu Kulam. The capacity of Iranamadu Scheme is 106,500 Ac.ft. The Capacity of Chemamadu is 2560.0Ac.ft and the capacity of Kanagarayan Kulam is 1100 Ac.ft. There are 64 Minor Tanks in this river basin. Alluvial soils are found in a strip along the Kanagarayan Aru spreading towards Paranthan area. Kanagarayan Aru River Basin was selected as the study area to investigate the performance of hydrological modifications.

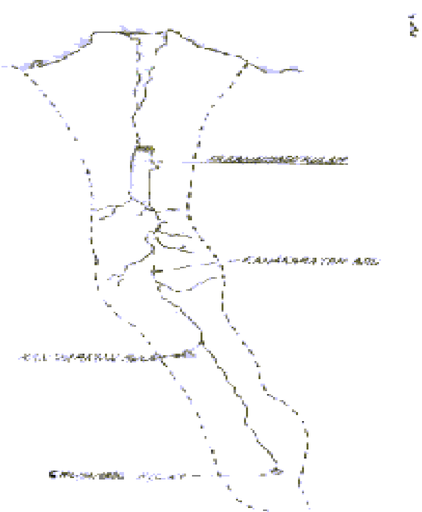

Fig 1.1 Kanagarayan Aru River Basin

### 1.2 Iranamadu Irrigation Scheme

Fig 1.2 Iranamadu Irrigation Scheme

The Iranamadu scheme was established in several stages since 1902 and presently it has the water holding capacity of 131 MCM to provide irrigation facilities to 9000 ha of paddy lands. Due to the conflict situation prevailed during the last 3 decades and inadequate funds made available for maintenance, satisfactory maintenance couldn't be carried out. In addition to this, severe damages caused by the heavy floods and conflict had worsened the situation. All the canals, control structures and agriculture roads were in a dilapidated condition. Due to such uncontrolled system, the water losses were very high, depriving cultivation to a significant extent during Yala session. Apart from this around 2500ha of paddy lands along the fringes are also cultivated using the drainage water from the Iranamadu filed. After resettlement in 2010, there was strong demand from main stakeholders including farmers to improve the system in order to utilize the scheme efficiency and effectively.

Restoration of the tank was commenced in 1902 and completed in 1920. The F.S.D was 22' at that time. Subsequently the tank was augmented to F.S.D 28' in 1952 and again in 1956 augmentation was done and F.S.D was brought up to 30'. Lastly the tank was augmented in 1977 to F.S.D 34'. There are 6nos of electrically operated pumps used to lift irrigate 1103 Acres. These have not functioned from 1990, due to stoppage of grid power supply.(Jaffna and Kilinochchi Water Supply and Sanitation Project (RRP SRI 37378))

### 1.3 Chemamadu Irrigation Scheme

Chemamadu Tank is situated in the Kanagarayan Aru River Basin. This tank impounds flow of the top most reaches of Kanagarayan Aru. The tank may have obtained its name from the "Shema" flowering plants often fund in the jungle. Then present tank was restored in 1958. The left bank and

Right bank channel system conveys supply for the development of 600 Acres of paddy cultivation. 200 farm families benefited in this tank. The length of bund is 5000 ft long. People left the area in 1997 due to security operation and now after 5 years they were returned to their original places and started their cultivation activities. It was found that bund and irrigation systems were damaged. The tank bund has been rehabilitated in 2012 under ADB funded CARE project. RB Sluice also reconstructed under the same project. Part of the cannel system also rehabilitated in 2012 under CARE project where cannel lining turn out structures causeway and FTO's have been constructed in LB & RB cannel and a trough has been constructed in LB cannel.

### 1.4 Kanagarayan Kulam Irrigation Scheme

Kanagarayan Kulam Tank is situated in the Kanagarayan Au River Basin. The present tank was in 1888-1896 original name said to be suggestive of one time colonist settles of the vanni. The "Rayans" located along with Pallavarayan and Akkarayan kulam. The left bank channel system conveys supply for the development of 314 acres of paddy cultivation. The present Kanagarayan Kulam was restored in 1896 and then breached in 1996 and again restored in 2000. It impounds flow of the top most reaches of a tributary of Kanagarayan Aru. The length of bund is 3500 long. 120 farm families were benefited in this tank. This tank bund and part of the cannel system have been rehabilitated under ENREP project during 2012-2013. During 2018 the bund has been proposed to rehabilitate by GA's fund.

## 2.0 Literature Review

### 2.1 Recent developments in hydrological modeling

Commonly model is a good representation of a system of the natural or man-made world that allows for estimate the properties of the system and predicts the future outcomes. There are three areas of recent developments in hydrological modeling: prediction in ungauged basins (PUBs), predicting responses at interior catchment points using distributed models, and estimate the impact of climate and land use change on hydrological prediction (Pechlivanidis et al., 2011). Majority of practical applications are from ungauged or poorly gauged catchments which have been identified as a scientific task for the current decade (2003-2012) (Sivapalan, 2003).

### 2.2 Rainfall Runoff Models

Catchment is a single unit, averages over catchment area represent variable (Beven, 2001). Empirical algebraic equations account of spatial variability of processes, inputs, boundary conditions, catchment geometric characteristics (Singh, 1995). Spatial variability boundary conditions, and catchment characteristics are used in distributed models however, often parameters are averaged mainly due to data availability (Beven, 2001). Distributed models make predictions that are distributed in space, with state variables that represent local averages, by discretizing the catchment into a number of elements and solving the equations (Singh and Frevert, 2006).

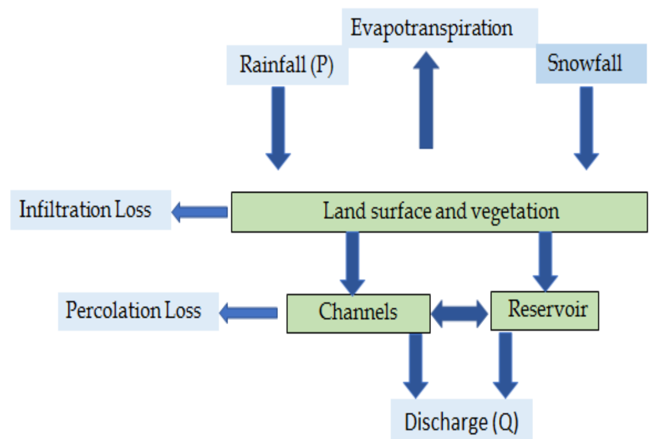


Fig2.1 Schematic representation of HEC-HMS model

### 2.3 Hydrological Models

Hydrological Modeling is a commonly used tool to estimate the basin's hydrological response due to precipitation. Various type of hydrological models from black box models which require less basin data to physically based models which require large amount of basin data have been developed (Chong, 2002).

The HEC-HMS, developed by Hydrologic Engineering center of U.S Army corps of Engineers (Najim,l, 2013) is a Hydrological model that supports both lumped parameter based modeling as well distributed parameter based modeling (Scharffenberg, and Fleming, 2006). HEC-HMS is a set of mathematical models to simulate the precipitation runoff-routing process of dendritic watershed system. HEC-HMS model can be applied to analyze the basin flow, urban flooding, flood frequency, flood warning system planning, reservoir spillway capacity, stream restoration, etc (U.S. Army Corps Engineers, 2008).

## 3.0 METHODOLOGY

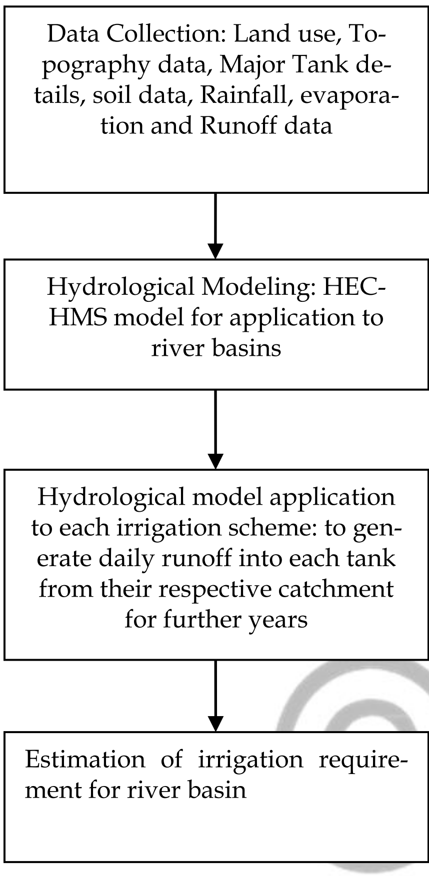


Fig 3.1 Flow chart of the Methodology

### 3.1 Flood Discharge

Flood Discharge was estimated for three river basins. Flood discharge capacity of the irrigation scheme network by the rational formula due to small nature of the catchment.
The Rational formula can be expressed as,

Q = C I A

Where

C = Runoff coefficient

I = Rainfall intensity for one hour expressed in inches per hour

A = Drainage area in Acs

The sizing of the canals can be done by the application of Manning equation assuming the steady flow conditions. However in this project the combined flow from the tributary canals eventually leads to the main canals and flow in the main canals become unsteady when the canals are entering the River. This is due to the tidal action of the river and the flow in the canal is influenced not only by the upstream flow conditions, but from the tidal action by the river. Therefore it is decided to design the main canals under gradually varying flow conditions assuming the unsteady flow conditions.

### 3.2 Manning Formula

The Manning formula can be expressed as,

V = 1/n R ^ $^{2/3}$ * S ^ $^{0.5}$ Where

R = Hydraulic Radius

S = Energy slope

V = Canal velocity

N = Drainage area in Acs

For designing the rivers under unsteady conditions, a hydraulic model based on the unsteady flow equations will be used during this study.

### 3.3 Observed Data

The daily rainfall data were collected for precipitation gauge stations of Iranamadu and near to Chemamadu and Kanagarayan kulam basin from meteorological department. The gauge stations are Iranamadu, vavunikulam and vavuniya. The Iranamadu basin 1: 50,000 sheets and digital data include land use patterns, area, location names, hydrological details and contour details. Basin terrain was determined according to contour details. Land use and ground cover, vegetation details were cross checked by field visit, digital data got from survey department and from the project report of Democratic Socialist Republic of Sri Lanka: Jaffna and Kilinochchi Water Supply and Sanitation Project and Sri Lanka: Water Resources Development Investment Program (Asian Development bank).

### 3.4 Data Collection

The study area sub basins are controlled by Kilinochci Irrigation Department and Vavuniya Irrigation department. Hydro data and investments data could be collected from there. Following Table 4.1 shows the capacity of each sub basins.

Table 4.1 Capacity of Sub basins

| No | Name of the Tank | D.S Division | Capacity (Ac.Ft) | Irrigable Area (Ha) | Catchment Area(sq.km) |
|---|---|---|---|---|---|
| 1 | Iranamadu Tank | Karachchi | 106,500 | 8,897.21 | 587.93 |
| 2 | Chemamadu Tank | Vavuniya | 2560 | 242-82 | 37.56 |
| 3 | Kanagarayan Kulam Tank | Vavuniya North | 1100 | 127.07 | 9.07 |

*(Source: Water Resources and Agriculture Development Strategy North East Province)*

GSJ: Volume 6, Issue 12, December 2018
ISSN 2320-9186


## 4.0 Data Analysis

### 4.1 HEC-HMS Model and Model Setup

The hydrological modeling system (HEC-HMS) is designed to simulate the precipitation-runoff process of dendritic drainage basins. The correct elements were applied to basin model. The basin model of the study area is shown in figure 4.1.

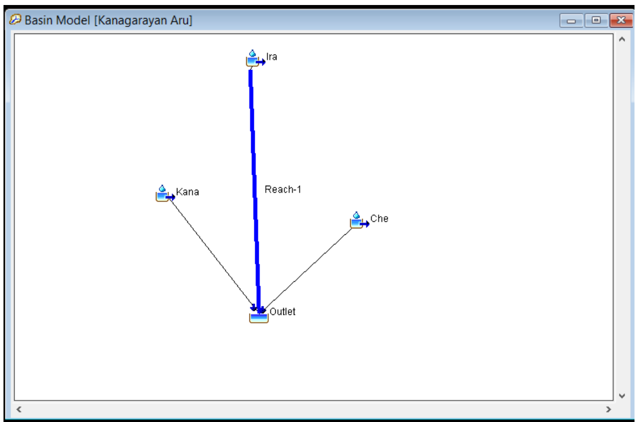


Figure 4.1 Basin Model of the Study Area

### 4.2 Basin and Sub Basin Areas

The catchment (basin) areas were collected from district irrigation departments. The sub basin areas are shown in figure 5.2

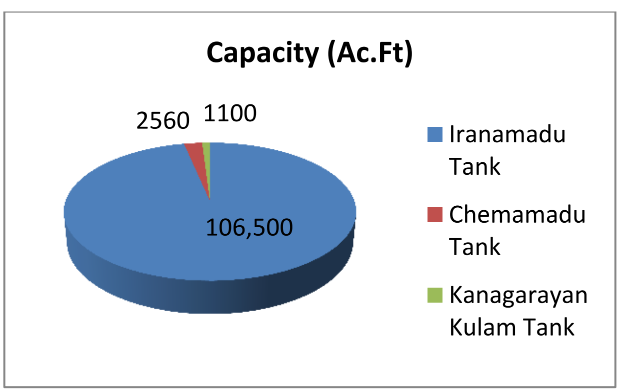


Figure 4.2 Area distribution of Kanagarayan aru river basin

### 4.3 SCS Curve Number

The SCS curve number was estimated according to land use, ground cover and hydrological soil group details. SCS curve numbers for each sub basin are given in the table 4.1.

Table 4.1- SCS Curve number for Sub basins

| Sub basin name | SCS CN |
|---|---|
| **Sub basin 1** | 82 |
| **Sub basin 2** | 86 |
| **Sub basin 3** | 86[1] |



### 4.4 HEC - HMS Outputs

HEC - HMS model outputs the runoff series for the sub basins of the Iranamadu basin for the simulation period 2016 June – 2018 June. Figure 4.3 shows basin model of Kanagarayan aru river basin.

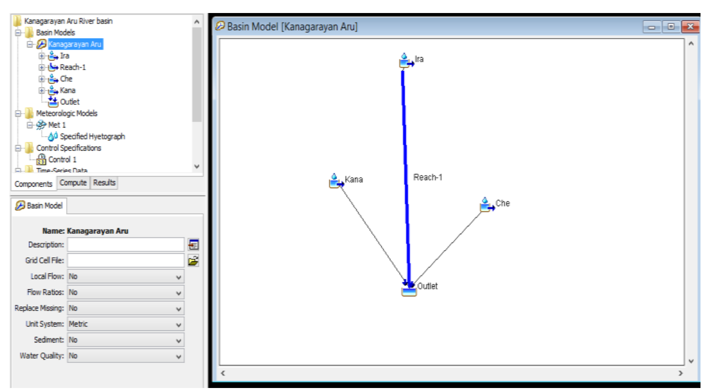


Figure 4.3 HEC-HMS basin model of Kanagarayan aru river basin.

GSJ: Volume 6, Issue 12, December 2018
ISSN 2320-9186



### 4.4.1 Metrologic Models

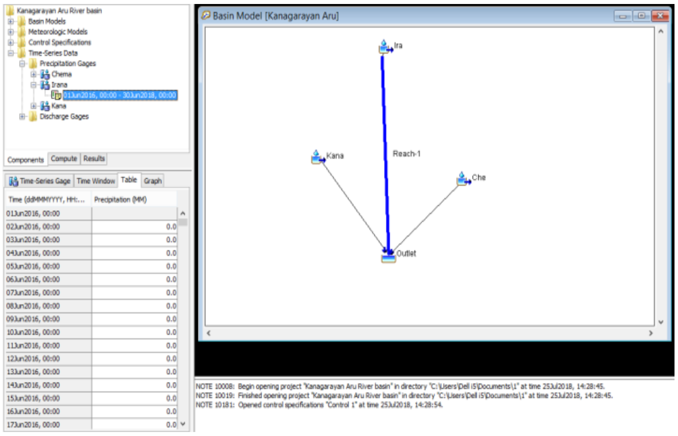

Figure 4.4 HEC-HMS Metrologic model

### 4.4.2 Precipitation Gauges

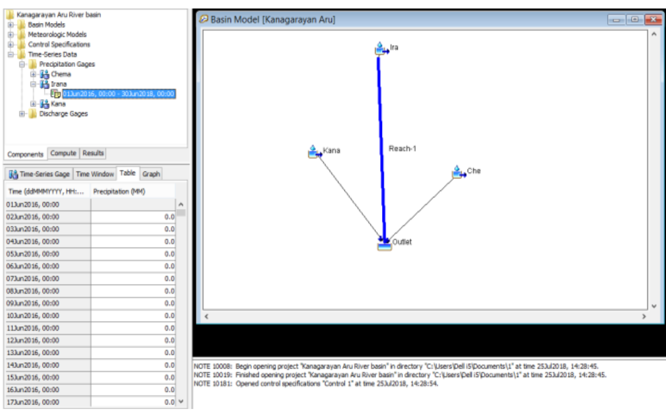

Figure 4.5 HEC-HMS Precipitation gauges

### 4.4.3 Global Summary

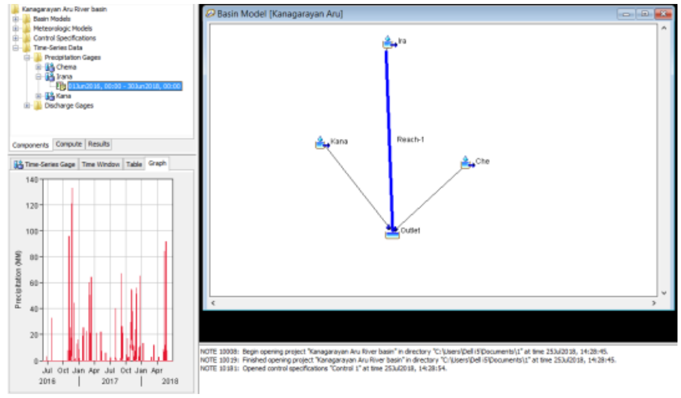

Figure 4.6 HEC-HMS Global Summary

### 4.4.4 Flow and Depth Graph for Iranamadu

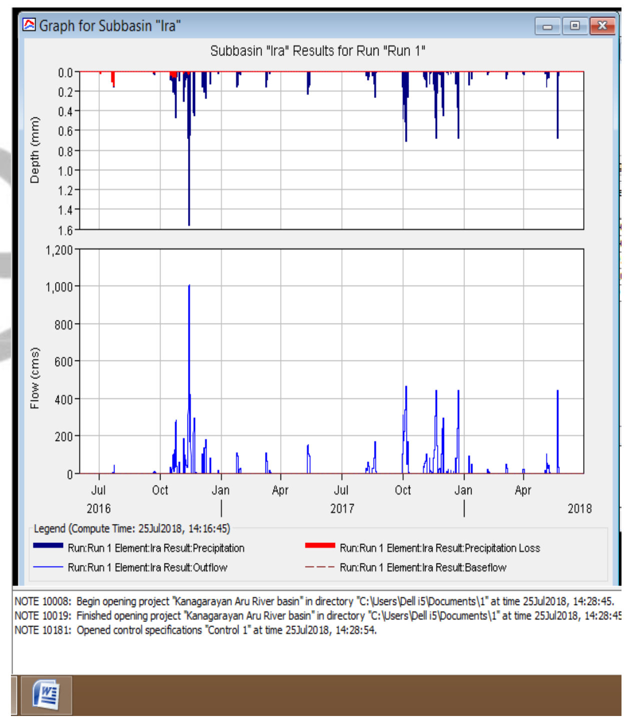


Figure 4.7 Flow and depth graph for Iranamadu

## 5. Conclusion

Model is useful to estimate the release from small tanks and required releases from canal into the tank. The study used the computed skill metrics of simulated stream flow against observation and found the consisticy

## 6. Reference

1. adb.org/sites/default/files/project-document/60279/44065-013-sri-iee-01.pdf
2. Agarwal, A, "A Data model with pe and post processor for HEC-HMS", Report of Graduate Studies, Texas A & M Univ. College station, 2005
3. Chong-yu Xu Text book of hydrological model,Uppsala university department of earth science and Hydrology, 2002.
4. Colombus, N., 1965. Viscous Model Study of saltwater intrusion in water table aquifer. Water resource research, Issue 1.
5. Cropwat Reference manual, 2009.
6. Data were Collected from Provincial Irrigation Department
7. DE Silva, M.M.G.T, Weerakoon, S.B.Herath S, Modeling of Event and continuous flow Hydrographs with HEC-HMS: a Case study in the Kelani River Basin Srilanka.
8. deva K Borah, M, ASCE: Jeffery, G Arnold: Maitreyee bera : Edward C, Krug and Xin-Zhong Liang, 2007, storm Event and Continuous Hydraulic Modeling for comprehensive and Efficient Watershed Smulations,
9. Gowthaman, S., Mafizur, R., and Sivakumar, S.S., "Performance Evaluation of Waste Water Treatment Plant: an analysis of FOG removal efficiency" , International Journal of Scientific and Engineering Research 1/2017; 8(1): pp 2084-2089, ISSN – 2229 – 5518
10. Halwatura D, Najim,M.M.M Application of the HEC-HMS Model for Runoff Simulation in a Tropical Catchment
11. Hamseen, M.H.M.and Sivakumar,S.S., 2016. Water Conflict Resolution in Multiple User Senarios in Mahakanadarawa Scheme in Sri Lanka.. International Journal of Scientific and Engineering Research, VII(2), pp. 130-136.
12. IIDP and IFAD-2013 Iranamadu Irrigation Development Project. Irrigation Scheme.
13. Janen, S.S., .and Sivakumaer,S.S., 2014. Ground Water Quality Improvement of Jaffna Peninsula of Sri Lanka by Regulating Water flow in the lagoon Mouths.. International Journal of Scientific & Engineering Research, Issue 5, pp. 973-978.
14. Janen, S.S., .and Sivakumaer,S.S., Sustainable Community Project Identification and Selection Based on the Experience Gained from Emergency Northern Recovery Project, Proceedings of International Conference on Contemporary Management-2014(ICCM-2014), Vol.1, pp 962-968, Faculty of Management Study, University of Jaffna Publication, ISSN – 2362 – 0536
15. Kirshanth, L., and Sivakumar, S.S. "Optimization of Water Resources in the Northern Province River Basins for Irrigation Schemes Used for Food Production in Sri Lanka" International Journal of Scientific and Engineering Research 7/2018; 9(7): pp 569-573, ISSN – 2229 – 5518
16. S., and Sivakumar, S.S., 2016. River for Jaffna-Cultivating Productive water from Saltwater Lagoons in Northern Sri Lanka-What the Water Balance of Elephant Pass Lagoon Demonstrates. International Journal of Scientific and Engineering Research, VII(2), pp. 137-142.
17. Kuganesan,S. and Sivakumar,S.S., 2015. Hypothesis of Cultivating Productive Water from Lagoons of Northern Sri Lanka.. International Journal of Advanced Research, III(9), pp. 637-345.
18. Kularam,S.,Thushyanthy,M., and Sivakumar, S.S., 2016. Importance of rehabilitation and Reconstruction of Irrigation Infrastructure,before the Introduction of pedma Cultivation under Iranamadu Irrigation Scheme of Northern Sri Lanka. International Journal of Scientific and Engineering Research, VII(7), pp. 288-293.
19. Long term Hydro Metrological Data in Srilanka, Data Book of Hydrological Cycle in Humid Tropical Eco system, Part 1, Ed K.Nakagawa, H. Edagawa, V. Nandakumar & Aoki.M Special Research Projection1995, and University of Tsukaba.
20. Navaneethakrishnan,S., and Sivakumar, S.S., 2015. Bibliometric Analysis of Water Resource Development and Utilization Based Research Studies in Sri Lanka. International Journal of Scientific and Engineering Research, VI(8), pp. 1432-1439.
21. Nirojan, K., Subramaniam, D.N., and Sivakumar, S.S., "Challenges in Utilization of Potential Groundwater and the Hypotheses of River for Jaffna for Cultivating Productive Water" , International Journal of Scientific and Engineering Research 10/2016; 7(10): pp 768-774, ISSN – 2229 – 55181
22. Nitharsan, U., Anusuthan, N., Thinojah, T., Mafizur, R., and Sivakumar, S.S., 2017. Freshwater Cultivation by Continuous Flushing of River Water through Elephant Pass Lagoonto Vadamarachchi Lagoon in Northern Sri Lanka. International Journal of Scientific & Engineering Research, VIII(2), pp. 705-710.
23. Ravi, V., Hareth, G.B.B., Manobavan, M., and Sivakumar, S.S., 'An Assessment of Ground Water Quality in Selected Dug Wells in Vavuniya Urban Council Limit through Water Quality Index' International Journal of Scientific and Engineering Research 04/2016; 7(4): pp1517-1526, ISSN – 2229 – 55181
24. Ravi, V., Hareth, G.B.B., Manobavan, M., Sivakumar, S.S., 'Management Plan to Reduce the Adverse Effects of Proximity of Dug Wells and Septic Tanks in Urban Area to Diminish Coli form Contamination' International Journal of Scientific and Engineering Research 03/2016; 7(3): pp507-513, ISSN – 2229 – 5518.
25. Scharffenberg, W.A and Fleming ,M.J "Hydraulic modeling system HEC- HMS user's Manual.US Army corps of Engineers, Institute for Water Resources Hydraulic Engineering Center, 2006.
26. Shaharam,K.S.,and Somaieh,T., 2012. Calibration of loss estimation methods in HEC-HMS for simulation of surface runoff (Case Study: Amirkabir Dam Watershed, Iran). Advances in Environmental Biology, VI(1), pp. 343-348.
27. Sivakumar, .S.S., (2002). Water resource development strategy of North East 2002/2012.
28. Sivakumar, S. S., "Ground Water Quality Improvement of Jaffna Peninsula of Sri Lanka by Regulating Water Flow in the Lagoon Mouths", International Journal of Scientific and Engineering Research, 04/2014; 5(4), pp973-978, ISSN – 2229 – 5518
29. Sivakumar, S.S., 'Flood Mitigation Strategies Adopted in Sri Lanka A Review' International Journal of Scientific and Engineering Research 03/2015; 6(2):pp607-611, ISSN – 2229 – 5518
30. Sivakumar, S.S., "Effective Utilization of Available Water Resource by Following Proper Irrigation Practices in Sri Lanka", International Journal of Scientific and Engineering Research. 08/2014; 5(8):210-215, ISSN – 2229 – 5518.
31. Sivakumar, S.S., (2002), Water Resources and Agriculture Development Strategy North East Province Volume 1 & 2.
32. Sivakumar, S.S., 'Irrigation Scheme Development and Management Strategy for Conflict Affected Northern and Eastern Province of Sri Lanka' International Journal of Scientific and Engineering Research 08/2015; 6(8): pp1004-1008, ISSN – 2229 – 5518.
33. Sivakumar, S.S., "Conjunctive Use of Surface and Groundwater for Economic Food Production", Voice for Change-Journal of Jaffna Managers Forum pp149-154, ISBN 978-955-4760-00-4 (2013)
34. Sivakumar, S.S., "Conjunctive Use of Surface and Groundwater to Improve Food Productivity in the Dry Zone Area", ENGINEER, Journal of Institution of Engineers Sri Lanka, Vol;XXXXVI, No.01, pp 21-29,January 2013, ISSN 1800-1122
35. Sivakumar, S.S., "Development Strategy and Food for Taught in Water and Agriculture Sector of Re-Emerging Conflict Affected Northern Sri

Lanka", Transaction of Institution of Engineers Sri Lanka Northern Provincial Centre 09/2014; Session 2013/2014:29-52.

36. Sivakumar, S.S., "Management Policy of Water Table in Dry Zone of Sri Lanka to Subsidise the Pain of Non Rice Crop Cultivators for the Food Productivity Improvement", RJSITM, The International Journal Research Publications, Volume 02, Number 09, pp, July-2013, ISSN:2251-1563
37. Sivakumar, S.S., "Policy alternatives of the management of minor and medium irrigation schemes to develop groundwater system in restricted catchments for the improvement in food productivity in the dry zone of Sri Lanka. Proceedings of National Conference on Water", Food Security and Climate Change in Sri Lanka Vol. 3, Page 73-88 (2009) IWMI Publication ISBN 978-92-9090-720-6
38. Sivakumar, S.S., "Post Conflict Development Strategies. 2012: Emergency Northern Recovery Project".
39. Sivakumar, S.S., "Reclamation of Land and Improve Water Productivity of Jaffna Peninsula of Northern Sri Lanka by Improving the Water Quality of the Lagoons" RJSITM. 2(08): p. 20-27.
40. Sivakumar, S.S., "Strategies for Catchment Development Master Plan and Economic Aspects of Water Resource Planning" International Journal of Scientific and Research Publications 07/2014; 4(7):1-5.
41. Sivakumar, S.S., "Strategy to be adopted in Preparation of National Water Resource Master Plan", International Journal of Scientific and Engineering Research. 06/2014; 5(6): pp578-591, ISSN – 2229 – 5518.
42. Sivakumar, S.S., "Water Management Strategies to be adopted in Sri Lanka to Improve Food Productivity to Accommodate the Population Growth", International Journal of Advancements in Research & Technology. 05/2014; 3(5):pp207-211, ISSN 2278 – 7763.
43. Sivakumar, S.S., "Water Resource and Agriculture Development Strategy-North East Province 2002/2012" Vol. 2. 2002: Irrigation Department.
44. Sivakumar, S.S., "Water Resource and Agriculture Development Strategy-North East Province 2002/2012" Vol. 1. 2002: Irrigation Department.
45. Sivakumar, S.S., "Water Utility and Management Policy for Effective Sharing of Natural Water Resource in the Costal Dry Zone of Sri Lanka in the North East Region". ENGINEER, Journal of Institution of Engineers Sri Lanka, Vol;XLVII, No.01, pp 37-42,January 2014, ISSN 1800-112
46. Sivakumar, S.S., Alternate management options of small scale surface water resource system to develop ground water system for the improvement in food productivity in Dry Zone of Sri Lanka. Proceedings of Workshop on Challenges in Groundwater Management in Sri Lanka. P63-72 (2011)
47. Sivakumar, S.S., Alternate management options of small scale surface water resource system to develop ground water system for the improvement in food productivity in Dry Zone of Sri Lanka. Proceedings of Workshop on Challenges in Groundwater Management in Sri Lanka. P63-72 (2011)
48. Sivakumar, S.S., Alternate management options of small scale surface water resource system to develop ground water system for the improvement in food productivity in Dry Zone of Sri Lanka. Proceedings of Workshop on Challenges in Groundwater Management in Sri Lanka. P63-72 (2011)
49. Sivakumar, S.S., Application of Electronic Spread Sheet and Water Balance Error Optimization Technique in Ground Water Model Study to Improve the Ground Water System in Restricted Area, International Journal of Advanced Research. 07/2014; 2(6): pp792-808, ISSN 2320 – 5407.
50. Sivakumar, S.S., Conjunctive Use of Surface and Groundwater to Improve Food Productivity in Restricted Ares. 2008, University of Moratuwa, Sri Lanka.
51. Sivakumar, S.S., Conjunctive Use of Surface and Groundwater to Improve Food Productivity in the Dry Zone Area. ENGINEER, Journal of Institution of Engineers Sri Lanka, Vol;XXXXVI, No.01, pp 21-29,January 2013, ISSN 1800-1122
52. Sivakumar, S.S., Engineer's Roll in Sustainable Recovery Process of Post (Natural) Disaster. Proceedings of International Conference on Contemporary Management-2014(ICCM-2014), Vol.1, pp 947-954, Faculty of Management Study, University of Jaffna Publication, ISSN – 2362 – 0536
53. Sivakumar, S.S., Groundwater balance study in a restricted catchments in Vavuniya to find effective recharge location by introducing new operational policy on minor / medium irrigation schemes. Seminar on Irrigation for the Centenary programme of Irrigation Department, P163-174(2001)
54. Sivakumar, S.S., Policy alternatives of the management of minor and medium irrigation schemes to develop groundwater system in restricted catchments for the improvement in food productivity in the dry zone of Sri Lanka. Proceedings of National Conference on Water, Food Security and Climate Change in Sri Lanka Vol. 3, Page 73-88 (2009) IWMI Publication ISBN 978-92-9090-720-6
55. Statistical Information Hand Book Northern Province, Secretariat Department -2012-2017.
56. Suthaharan, N., Ketheesan, B., Ratnaweera, H.C., and Sivakumar, S.S., "Challenges in Utilizing Water Resources in Lower Reaches of Kanakarayanaru of Northern Sri Lanka for Efficient and Equitable Water Allocation" , International Journal of Scientific and Engineering Research 7/2018; 9(7): pp 821-826, ISSN – 2229 – 5518
57. Tharmendra, P., Sivakumar, S.S., 'Organizational Management of Groundwater by Farmers for the Sustainable Utilization of Water Resource in Jaffna District of Northern Sri Lanka' International Journal of Scientific and Engineering Research 01/2016; 7(1): pp944-948, ISSN – 2229 – 5518
58. Tharmendra, P., Sivakumar, S.S., 'Organizational Management of Groundwater by Farmers for the Sustainable Utilization of Water Resource in Jaffna District of Northern Sri Lanka' International Journal of Scientific and Engineering Research 01/2016; 7(1): pp944-948, ISSN – 2229 – 5518
59. Thileepan, K., and Sivakumar, S.S., "Impact of Water Resource Auditing - Intergrated Development Approch - to Mitigate Water Related Disasters in the Vavuniya Divisional Secretariat's Division in Northern Sri Lanka" , International Journal of Scientific and Engineering Research 8/2018; 9(8): pp 43-49, ISSN – 2229 – 5518
60. Thinojah, T., and Sivakumar, S.S., "Water Resource Development in Jaffna Peninsula" Transactions of Institution of Engineers Sri Lanka, Northern Chapter 11/2016; Session 2015/2016:70-71.
61. US Army Corps of Engineers, Hydrological Engineering Center, HEC-HMS Technical Reference Manual, March 2000 Chandrasekara, C.M.K.N.K., Weerasinghe,K.D.N.,Ranjana,U.K.,Piyadasa and Sumith Pathirana, 2014. Salinity,pH and Turbidity changes of water in the Negambo lagoon.Colombo Arts. Journal of Social Sciences and Humanities, pp. 1-11.
62. Vijakanth, V., Sivakumar, S.S., and Ratnaweera, H.C., "Water Availability Study of Groundwater in Jaffna Peninsula of Northern Sri Lanka" , International Journal of Scientific and Engineering Research 1/2017; 8(1): pp 1563-1567, ISSN – 2229 – 5518
63. Visnuvarthanan, N., Sivakumar, S.S., 'Cultivating Productive Water in Valukai Aru Catchment in Valikamam Division of Jaffna District of

Northern Sri Lanka' International Journal of Scientific and Engineering Research 01/2016; 7(1): pp1045-1048, ISSN – 2229 – 5518

64. WEAP,User-Guide http://www.weap21.org/index.asp?action=200)